SYSTEM AND METHOD FOR LOW POWER HAPTIC FEEDBACK

CROSS-REFERENCE TO RELATED APPLICATIONS

This patent application claims priority to U.S. Provisional Application Ser. No. 60/474,434, filed May 30, 2003, the entirety of which is hereby incorporated by reference.

FIELD OF THE INVENTION

The present invention generally relates to haptic feedback. The present invention more specifically relates to kinesthetic low power force feedback devices.

BACKGROUND

Many conventional buttons, sliders, dials, and other controls provide tactile or haptic feedback to the user. Feedback may be provided to the user by mechanical elements, such as detents, which are fabricated into the device. The feedback provided by devices relying primarily or solely on mechanical elements is rarely variable and, if variable, is not controllable in real time and hence is not programmable.

Some conventional controls comprise active or resistive (also referred to as passive) feedback, which is controllable in real time, see, e.g., U.S. Pat. No. 5,220,260. The addition of controllable haptic feedback to a device normally requires an actuator, and the actuator requires a power source. In devices designed for low power consumption, such as cell phones and other handheld devices, the power necessary to supply the actuator may be difficult to provide.

Thus, a need exists for systems and methods for providing controllable haptic feedback while minimizing power requirements.

SUMMARY

Embodiments of the present invention provide systems and methods for low power consumption haptic feedback. In one embodiment according to the present invention, a device comprises a manipulandum and a haptic effect generator in communication with the manipulandum. The haptic effect generator is operable to provide a first haptic profile associated with a first mechanical configuration and a second haptic profile associated with a second mechanical configuration. The device may also comprise an actuator in communication with the haptic effect generator and operable to switch the haptic effect generator between the first haptic profile and the second haptic profile.

Further details and advantages of the present invention are set forth below.

BRIEF DESCRIPTION OF THE FIGURES

These and other features, aspects, and advantages of the present invention are better understood when the following Detailed Description is read with reference to the accompanying drawings, wherein:

FIG. **1**A is a schematic diagram illustrating a knob with programmable detent profiles in one embodiment of the present invention;

FIG. **1**B is a sectional view showing a first channel having surface features configured to provided a first haptic profile;

FIG. **1**C is a sectional view showing a second channel having surface features including depressions and a stop, configured to provided a second haptic profile;

FIG. **1**D is a sectional view showing a channel configured to provided a further haptic profile;

FIG. **1**E is a schematic diagram illustrating a knob with programmable detent profiles in another embodiment of the present invention;

FIG. **2** is an schematic diagram of a resistive actuator with programmable friction in one embodiment of the present invention;

FIG. **3** is a flowchart illustrating a method for controlling the resistive actuator of FIG. **2** in one embodiment of the present invention;

FIGS. **4** and **5** are schematic diagrams illustrating a programmable surface feel in one embodiment of the present invention;

FIGS. **6** and **7** are schematic diagrams illustrating a programmable surface feel in another embodiment of the present invention; and

FIG. **8** is a flowchart illustrating a process for controlling the operation of an actuator, such as the actuator shown in FIGS. **6** and **7**, in one embodiment of the present invention.

DETAILED DESCRIPTION

Embodiments of the present invention comprise systems and methods for low power haptic feedback. There are a variety of systems and methods according to the present invention.

One device according to the present invention comprises a manipulandum, a haptic effect generator, and an actuator. The device may be configured such that the haptic effect generator is in communication with the manipulandum. The manipulandum may be a knob, a slider, a push button, a joystick, or other manipulandum. The haptic effect generator may be operable to provide at least two haptic profiles—one associated with a first mechanical configuration and another associated with a second mechanical configuration. The two haptic profiles may be configured in any suitable manner. For example, they may be independent, or they may be combined in one or more files, data sets, records, or transmissions.

The actuator may comprise a solenoid, DC motor, shape memory alloy (SMA), or other suitable actuator. The actuator may be in communication with the haptic effect generator, and may be operable to switch the haptic effect generator between the first haptic profile and the second haptic profile.

The haptic effect generator may be configured in any suitable manner. For example, one haptic effect generator comprises a surface. The surface comprises two channels, which are substantially parallel to one another. Each channel comprises a plurality of surface features (e.g., depressions, protrusions, stops, etc.), which define a haptic profile. The haptic effect generator in such an embodiment also comprises a follower. A follower is an element configured to follow a surface or surface feature. IN one embodiment, the follower may be configured to follow a channel. In another embodiment, the follower may be configured to follow a path along a surface, or paths on multiple surfaces, that is not within a channel. For example, a follower may be configured to follow the surface of a cam.

An actuator in communication with the follower is operable to move the follower between the channels (or the two paths) and thereby change the haptic profile. The surface may comprise more than two channels.

In another embodiment, the haptic effect generator comprises a first surface comprising a first plurality of surface